CAMBRIDGE INTERNATIONAL EXAMINATIONS

Pre-U Certificate

MARK SCHEME for the May/June 2014 series

9794 MATHEMATICS

9794/03 Paper 3 (Applications of Mathematics), maximum raw mark 80

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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International Examinations

1	Mid-points 1.7, 1.9, 2.1, 2.3, 2.5 $\bar{x} = \frac{206.2}{100} = 2.062\,(\text{kg})$ $s = \sqrt{\frac{431.16}{100} - 2.062^2}$ $\therefore s = \sqrt{0.059756} = 0.244(45...)\,(\text{kg})$	M1 A1 M1 B1 A1 [5]	With no working shown allow only correct answers (to 3 sf or better). Use of mid-points seen or implied. c.a.o. Use of correct formula for standard deviation; may be implied. Correct Σfx^2 s.o.i. c.a.o. Allow unbiased estimator (0.24568…) for full marks. 2.06 used for sd (gives 0.2607… or unbiased 0.2620…) gets max M1 B1 A0.
2 (i)	$\text{P}(A \cap B) = \text{P}(A) + \text{P}(B) - \text{P}(A \cup B)$ $= 0.6 + 0.5 - 0.8 = 0.3$	M1 A1 [2]	Probability rule applied, s.o.i. c.a.o. Accept solutions based on Venn diagrams.
(ii)	$\text{P}(B\|A) = \frac{\text{P}(A \cap B)}{\text{P}(A)}$ $= \frac{0.3}{0.6} = 0.5$	M1 A1 [2]	Conditional probability rule applied, s.o.i. ft **(i)** provided both $\text{P}(A \cap B)$ and $\text{P}(B)$ lie between 0 and 1.
(iii)	A and B are independent since $\text{P}(B\|A) = \text{P}(B) = 0.5$	B1 [1]	ft **(ii)**. Must be supported by explicit numerical evidence. Accept alternatives, e.g. $\text{P}(A \cap B) = \text{P}(A) \times \text{P}(B)$, with evidence.
3 (i)	$p = 1 - (0.4 + 0.3 + 0.1) = 0.2$	B1 [1]	
(ii)	$(1 \times 0.4) + (2 \times 0.3) + (n \times 0.2) + (7 \times 0.1) = 2.5$ $\therefore 0.2n + 1.7 = 2.5$ $\therefore 0.2n = 0.8$ $\therefore n = 4$	M1 A1 [2]	Use of formula for $\text{E}(X)$ s.o.i. to set up an equation in n. c.a.o.
(iii)	$\text{E}(X^2) = (1^2 \times 0.4) + (2^2 \times 0.3) + (4^2 \times 0.2) + (7^2 \times 0.1) = 9.7$ $\text{Var}(X) = 9.7 - 2.5^2 = 3.45$	B1 M1 A1 [3]	Correct expression for $\text{E}(X^2)$ s.o.i. ft c's n. Use of formula for $\text{Var}(X)$ s.o.i. c.a.o.
4 (i)	$\text{E}(X) = 20 \times 0.4 = 8$	B1 [1]	
(ii)	State or imply Bin(20, 0.4) $\text{P}(X = 8) = 0.5956 - 0.4159$ $= 0.1797$	B1 M1 A1 [3]	May be awarded elsewhere if not here. Use of tables for $\text{P}(X \le 8) - \text{P}(X \le 7)$ or formula for $\text{P}(X = 8)$. c.a.o
(iii)	$\text{P}(X \ge 8) = 1 - 0.4159$ $= 0.5841$	M1 A1 [2]	Attempt $1 - \text{P}(X \le 7)$ c.a.o

5	**(i)**	Recognise combination problem. ${}^{15}C_4 = \dfrac{15!}{11!4!} = 1365$	M1 A1 [2]	 c.a.o.
	(ii)	Recognise implication of "no restrictions". $15^4 = 50625$	M1 A1 [2]	 c.a.o.
	(iii)	$\dfrac{15\times14\times13\times12}{15^4} = \dfrac{32760}{50625} = \dfrac{728}{1125} = 0.647(11...)$	M1 M1 A1 [3]	Correct numerator. Correct denominator; ft **(ii)**. c.a.o.
6	**(i)**	$D \sim \text{N}(8.3, 0.20^2)$ $\text{P}(8.1 < D < 8.3) = \text{P}\left(\dfrac{8.1-8.3}{0.20} < Z < \dfrac{8.5-8.3}{0.20}\right)$ $= \Phi(1.0) - \Phi(-1.0)$ $= 0.8413 - (1 - 0.8413)$ $= 0.6826$	 M1 M1 B1 M1 A1 [5]	 Standardising, either term. Relevant difference of 2 terms s.o.i. Correct table look-up: 0.8413 seen. 1 – … to deal with negative z value.
	(ii)	Now $D \sim \text{N}(\mu, \sigma^2)$ $\text{P}(D < 8.5) = 0.88 \Rightarrow \dfrac{8.5-\mu}{\sigma} = 1.175$ $\text{P}(D < 8.1) = 0.10 \Rightarrow \dfrac{8.1-\mu}{\sigma} = 1.282$ $\therefore\ \mu + 1.175\sigma = 8.5$ and $\mu - 1.282\sigma = 8.1$ $\therefore\ 2.457\sigma = 0.4$ $\therefore\ \sigma = 0.1628(0\ldots)$ $\therefore\ \mu = 8.5 - 1.175 \times 0.1628 = 8.3087$ or $\mu = 8.1 + 1.282 \times 0.1628$	 M1 B1 A1 M1 A1 A1 [6]	 Set up at least 1 equation for μ and σ. 1.175 and/or (–)1.282 seen. Both equations correct. Attempt to eliminate either μ or σ. One of σ or μ found. c.a.o. The other found. c.a.o. Allow 0.163 used and a.w.r.t. 8.31
7		At max height $0 = 30^2 - 2 \times 10 \times h$ $\therefore\ h = 45\,\text{m}$ On return to ground level $-30 = 30 - 10 \times t$ $\therefore\ t = 6$ sec	 M1 A1 A1 M1 A1 [5]	 Use of an appropriate '*suvat*' equation. Correct equation. Correct outcome. Allow $g = 9.8$, giving $h = 45.918$ Correct use of a second appropriate '*suvat*' equation. Allow any valid method, e.g. (time to max ht) × 2. Correct outcome. Allow $g = 9.8$, giving $t = 6.122$

8 (i)	$\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 + \mathbf{F}_4 = 0$ $\therefore (5\mathbf{i} - 8\mathbf{j}) + (-3\mathbf{i} - 4\mathbf{j}) + (6\mathbf{i} + 6\mathbf{j}) + \mathbf{F}_4 = \mathbf{0}$ $\therefore \mathbf{F}_4 = (-8\mathbf{i} + 6\mathbf{j})$	M1 A1	[2]	Sum of 4 forces set equal to **0** o.e. c.a.o.
(ii)	$\lvert\mathbf{F}_4\rvert = \sqrt{(-8)^2 + 6^2}$ $= 10\,\text{N}$ $\theta = inv\tan\left(\frac{6}{-8}\right)$ $= 143(.13\ldots)°$	M1 A1 M1 A1	[4]	Use of Pythagoras. ft **(i)**. Correct use of inverse tan (or cos or sin). ft **(i)**, but not c's magnitude. Must have a clear reference direction. Allow sketch as evidence if convincing.
9 (i)	Diagram showing weight, normal contact force and friction, and no others	B1	[1]	
(ii)	Resolve perpendicular to slope: $N = mg\cos\theta$ N2L used & resolve down slope: $ma = mg\sin\theta - F$ Friction law: $F = \mu N$ $\therefore ma = mg\sin\theta - \mu mg\cos\theta$ $\therefore a = g(\sin\theta - \mu\cos\theta)$	 B1 M1 B1 M1 A1	[5]	 Equation of motion with 3 terms, and at least 2 correct. Condone consistent sin/cos error. Limiting friction only. Attempt to eliminate N and F, and cancel m. c.a.o.
(iii)	If $\mu > \tan\theta$ then the particle will not move.	B1	[1]	
10 (i)	$v = \int(12 - 6t)\,\text{d}t$ $= 12t - 3t^2\ (+c)$ $v = 0$ when $t = 0\ \therefore c = 0$ When $t = 4$, $v = 48 - 48 = 0\,\text{ms}^{-1}$	M1 A1 M1 A1	[4]	Set up integral for v. Correct integration. Condone omission of "c". "c" dealt with explicitly. c.a.o. from correctly integrated a. Accept correct answer obtained from a definite integral.
(ii)	$x = \int_0^4(12t - 3t^2)\,\text{d}t$ $= (6t^2 - t^3)\Big\rvert_0^4$ $= (96 - 64) - (0) = 32\,\text{m}$	M1 A1 A1	[3]	Correct integral of c's v, including limits (which may appear or be dealt with later). Correct integration. ft c's v. c.a.o. following use of limits or explicit treatment of "c".
(iii)	When $x = 0$, $6t^2 - t^3 = 0$ $t \neq 0\ \therefore t = 6$ sec $\therefore v = 72 - 108 = -36\ \text{ms}^{-1}$	M1 A1 A1	[3]	Equation for $x = 0$. ft c's expression for x in **(ii)** only if obtained by integration. Condone omission of consideration of "c" (=0). Solved and non-zero solution chosen. c.a.o.

11 (i)	N2L & Resolve vertically for either particle	M1		Accept use of $g = 9.8$ throughout.
	$0.3a = 0.3g - T$	A1		
	$0.2a = T - 0.2g$	A1		
	$0.5a = 0.1g = 1$	M1		Eliminate either T or a.
	$\therefore a = 2$ ms^{-2}	A1		Correct value for one. c.a.o.
	$\therefore T = 0.3 \times 10 - 0.3 \times 2 = 2.4$ N	A1	[6]	Correct value for the other. c.a.o.
	ALTERNATIVE:			
	N2L for whole system	M1		Allow 1 error.
	$(0.3 + 0.2)a = 0.3g - 0.2g$	A1		All correct.
	$\therefore a = 2$ ms^{-2}	A1		c.a.o.
	N2L & Resolve vertically for either particle	M1		
	$0.3a = 0.3g - T$ or $0.2a = T - 0.2g$	A1		All correct. ft c's a.
	$\therefore T = 2.4$ N	A1		c.a.o.
(ii)	$v^2 = 0^2 + 2 \times 2 \times 2.25 = 9$	M1		Use of appropriate '*suvat*' equation.
	$\therefore v = 3$ ms^{-1}	A1	[2]	ft c's a.
(iii)	$I = (0.3 \times 3) - (0)$	M1		Use of Impulse = change in momentum.
	$= 0.9$ Ns	A1	[2]	ft c's v, including units. Allow –0.9 and/or kgms^{-1}.
(iv)	$0.9 = P \times 0.005$	M1		Use of Impulse = force × time, o.e.
	$\therefore P = 180$ N	A1	[2]	ft c's I. Allow –180.